PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Thomas Holtzman Williams | Docket Number:

Serial Number: 10/697,393 | Examiner: Jean B. Corrielus

Filed: 30 Oct 2003 | Art Unit: 2611

Title: **Digital Transmission System Using Non-Orthogonal Matrices**

Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

RESPONSE TO OFFICE ACTION

Dear Sir:

Responsive to Office Action mailed June 8, 2009 applicant respectfully submits this Response to Office Action

Amendments to the Specification begins on page 2 of this paper**.**

Amendments to the Claims begin on page 6 of this paper.

Amendments to the Drawings are the last 2 pages of this paper.

Remarks begin on page 5 of this paper.

Amendments to the Specifications

1. Page 1, first full paragraph:

"Field of the Invention

The present invention pertains to digital modulation techniques for sending data through wired and wireless channels and specifically to techniques that use non-orthogonal matrices to process a transmitted signal. "This patent application ~~is a continuation~~ claims priority of provisional US patent application 60/422,308 filed on October 30, 2002."

2. Page 4, lines 5-11: "Additionally, the present invention may be comprised of a two-dimensional transmission matrix that is over-determined, creating a transmit symbol sequence, which contains more symbols than are in the input symbol sequence. The additional (excess) symbols are redundant symbols. Corrupted symbols in the received symbol sequence may be discarded, and replaced by redundant uncorrupted symbols. A recovery matrix is formed by computing an inverse of a transmission matrix that has been modified by dropping ~~rows~~ columns corresponding to corrupted terms in the received symbol sequence."

3. Page 9, line 6 to page 10, line 4: "Fig 3 is a numeric matrix multiplication example 300 using a non-orthogonal over-determined matrix, which can be referred to as a "mother" matrix. An input symbol sequence 302 with 5 terms has been formed from data. A two dimensional mother transmission matrix 304 is comprised of non-orthogonal rows. Note that the transmission matrix 304 has 6 columns but only 5 rows, so it is an over-determined matrix. A transmit symbol sequence 306 is created by multiplying the input symbol sequence 302 by the transmission matrix 304. The use of an over-

determined transmission matrix creates 6 terms in the transmit symbol sequence 306 from only 5 terms in the input symbol sequence 302. This 6-term transmit symbol sequence is sent over a signal path. Assume, for example, that the 5th symbol (the term with a value of –2) has been corrupted in transmission, and has therefore been omitted from a truncated received symbol sequence 308. The original input symbol sequence may still be recovered by multiplying the truncated received symbol sequence by a daughter inverse recovery matrix. Dropping the ~~row~~ column of the mother transmission matrix 304 that corresponds to the corrupt term in the truncated received symbol sequence creates the daughter matrix. If the 5^{th} ~~row~~ column, corresponding to the 5^{th} corrupt received term, is removed from the transmission matrix 304, a daughter transmission matrix with the corrupt ~~row~~ column removed 310 is created. It has been labeled C5 to designate that the 5^{th} column is removed. If the C5 inverse is computed, a recovery matrix 312 is found. The output symbol sequence 314 is computed without error by multiplying the truncated received symbol sequence 308 by ~~the inverse of the truncated daughter transmission matrix~~ the recovery matrix 312."

4. Page 12 lines 8-14: "It is also possible to transform a transmit symbol sequence a second time ~~to place the symbols into the frequency domain~~ with a frequency transform before transmission. This can be accomplished by multiplying the transmit symbol sequence by a matrix that performs a discrete inverse Fourier transform (DIFT). Another equivalent method to do the same ~~time to frequency~~ operation would be to do an IFFT. Thus, the transmit symbol sequence may be ~~transmitted in the frequency domain~~ frequency transformed and the modulation technique may be called "Frequency Domain Inverse Matrix Modulation" (FDIMM). It is known is the art that the FFT transform

produces similar results as the IFFT. Thus, an IFFT can be performed at the transmitter and the FFT performed at the receiver. Alternately, the FFT can be performed at the transmitter and the IFFT performed at the receiver. Either transform pair reproduces the input data.

5. Page13 top to page 14 line 6: "Fig 5 is another block diagram 500 of the present invention. The signal flow starts at step 502. At step 504 a data sequence to be transmitted is loaded. At step 506 an input symbol sequence is formed from the data sequence. At step 508 a non-orthogonal mother matrix multiplies the input symbol sequence to create an intermediate transmit symbol sequence. The matrix may be over-determined, creating more output symbols than input symbols. In step 510 the intermediate transmit symbol sequence is ~~converted into the frequency domain~~ frequency transformed using another matrix multiply that performs the DIFT. The equivalent result could be achieved with an IFFT operation. At step 512 a guard interval (or cyclic extension) is optionally added to the transmission to simplify equalization in the presence of channel echoes. At step 514 ~~the~~ a transmit symbol sequence is modulated and up-converted in frequency for transmission ~~with the transmit symbols sent sequentially in frequency~~. In step 516 the transmit symbol sequence is transmitted over a signal path. In step 518 a received symbol sequence is captured. In step 520 the received symbol sequence is down-converted and demodulated in a reverse of step 514. If necessary, equalization and timing recovery can also be accomplished in step 520. At step 522 the data are ~~converted from time domain symbols into frequency domain symbols~~ inverse transformed in a reversal of step 510. The guard interval is discarded. At step 524 the badly corrupted symbols are excised. A determination of which symbols to discard can

be made by analyzing a training signal passed through the channel to discover frequency-selective fades. Additionally, mildly corrupted symbols may be combined to reduce the affects of noise by averaging. At step 526, removing the columns from the mother matrix that correspond to the corrupted terms in the received symbol sequence creates a daughter recovery matrix. If terms have been combined to reduce noise in the received symbol sequence, the corresponding ~~rows~~ columns are combined in the mother matrix to make a daughter matrix. Also at step 526, a recovery matrix is created from the daughter matrix by computing the inverse matrix. At step 528 the recovery matrix multiplies the received excised/combined symbol sequence to create an output symbol sequence. At step 530 the output data sequence is made from the output symbol sequence. At step 532 the output data sequence is delivered and the end is reached."

6. Page 14, lines 9 to 14: "Another improvement can be made to the block diagram of ~~Fig5~~ Fig 5 by using interleaving to provide additional protection from deep channel fades, which typically attenuate several adjacent frequency domain symbols. Frequency domain symbols are also known as harmonic carriers (HCs). Interleaving could be performed at step 506 after the symbols were formed, and de-interleaving could be performed at step 524 prior to symbol excision."

Amendments to the Claims

All prior claims are canceled. This listing of claims will replace all prior versions and listings of claims in the application. :

Listing of Claims

What I claim is:

1. (Canceled)

2. (Canceled)

3. (Canceled)

4. (Canceled)

5. (Canceled)

6. (Canceled)

7. (Canceled)

8. (Canceled)

9. (Currently Amended) A method for transmitting digital information in a data communication system comprising:
~~Comprising:~~
providing an input data sequence;
converting the input data sequence into an input symbol sequence;
multiplying the input symbol sequence by a non-orthogonal over-determined transmission matrix to produce a transmit symbol sequence;
modulating and up-converting the transmit symbol sequence using a modulator and up-converter;
transmitting the transmit symbol sequence in response to the modulating and up-converting;
receiving said transmit symbol sequence;
down-converting and demodulating said received symbol sequence;
excising corrupt symbols in the received symbol sequence in response to the down-converting and demodulating to produce a truncated received symbol sequence ~~and excised corrupt symbols~~;
creating an inverse recovery matrix based on said ~~excised~~ corrupt symbols and the transmission matrix;
multiplying the truncated received symbol sequence by the inverse recovery matrix to produce an output symbol sequence;
converting the output symbol sequence into an output data.

10. (Currently Amended) A method for transmitting digital information in a data communication system comprising:
~~Comprising:~~
providing an input data sequence;
converting the input data sequence into an input symbol sequence;
multiplying the input symbol sequence by a non-orthogonal over-determined matrix to produce an intermediate transmit symbol sequence;
converting the intermediate transmit symbol sequence with a~~n inverse Fourier~~ frequency transformer to a transmit symbol sequence;
modulating and up-converting the transmit symbol sequence;
transmitting the transmit symbol sequence in response to the modulating ~~modulation~~ and up-converting;
receiving a received symbol sequence responsive to the transmitting;
down-converting and demodulating the received symbol sequence;
converting the received symbol sequence with a ~~Fourier transformer to frequency domain symbols~~ inverse frequency transformer in response to the down-converting and demodulating;
excising corrupt symbols in the frequency domain symbols to produce truncated symbols;
creating a recovery matrix based on said ~~excised~~ corrupt symbols and over-determined matrix;
multiplying the ~~frequency domain~~ truncated symbols by the recovery matrix to produce an output symbol sequence;
converting the output symbol sequence into an output data. ~~;~~

11. (Currently Amended) A method for transmitting digital information according to claim ~~2~~ 10 further comprising a step of adding a guard interval to said ~~frequency domain~~ frequency transformed symbols before the transmitting step.

12. (Currently Amended) A method for transmitting digital information according to claim ~~2~~ 10 further comprising a step of combining ~~frequency domain~~ frequency transformed symbols after the step of excising.

13. (New) A method for transmitting digital information according to claim 9 further comprising a step of inserting an identity matrix into said non-orthogonal over-determined transmission matrix.

14. (New) A method for transmitting digital information according to claim 9 wherein said inverse recovery matrix is a pseudo-inverse of the transmission matrix.

Remarks

Reconsideration is respectfully requested.

Claims 1-8 are canceled. Claims 9-14 are pending in this application. Claims 9 - 12 are currently amended. Claims 9 – 12 have been re-written to be method claims. Claims 13 and 14 are newly added.

Claim 13 is supported by text from page 14, line 15 to page 15, line 11.

Claim 14 is supported by text from page 11, line 7-11.

In the art that an IFFT is conventionally used at the transmitter to convert OFDM symbols before transmission, and that a FFT is used at the receiver to recover the transmission. However it functions equally well to use a FFT at the transmitter and a IFFT at the receiver. Thus the term "frequency transformed" designates that either a FFT or an IFFT may be used at the transmitter provided the inverse transform is used at the receiver.

The absence of additional patentability arguments should not be construed as either a disclaimer of such arguments or that such arguments are not believed to be meritorious.

Applicant believes no new material has been added.

Applicant believes the application to be in condition for allowance, and such action is earnestly requested.

Dated this 16th day of July, 2009.

Respectfully submitted:

Thomas H. Williams

_____

20491 SW Skiver St
Beaverton, OR 97007
303-817-1895

_____

\Thomas H. Williams\

ANNOTATED SHEET

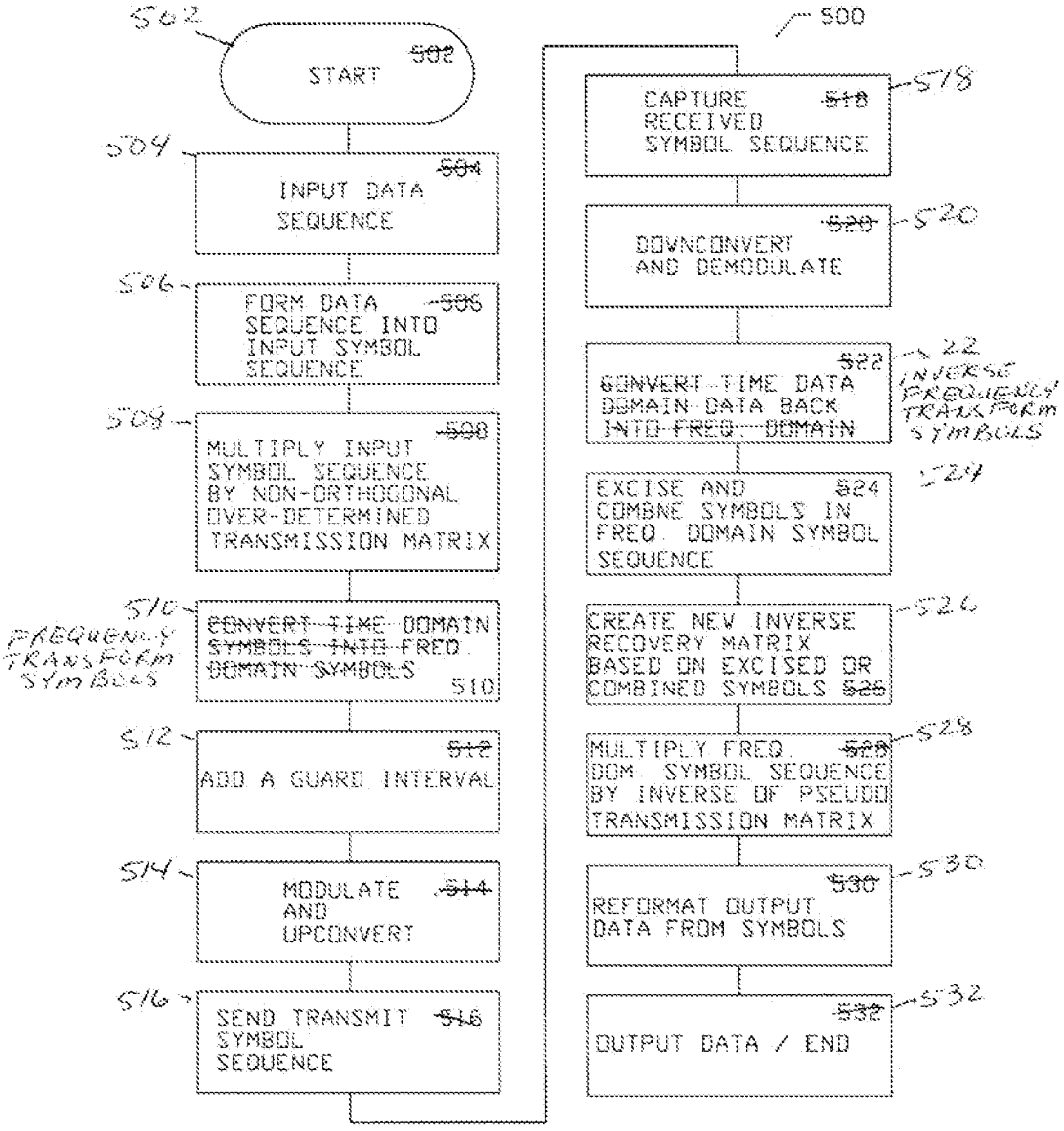

FIG 5

REPLACEMENT SHEET

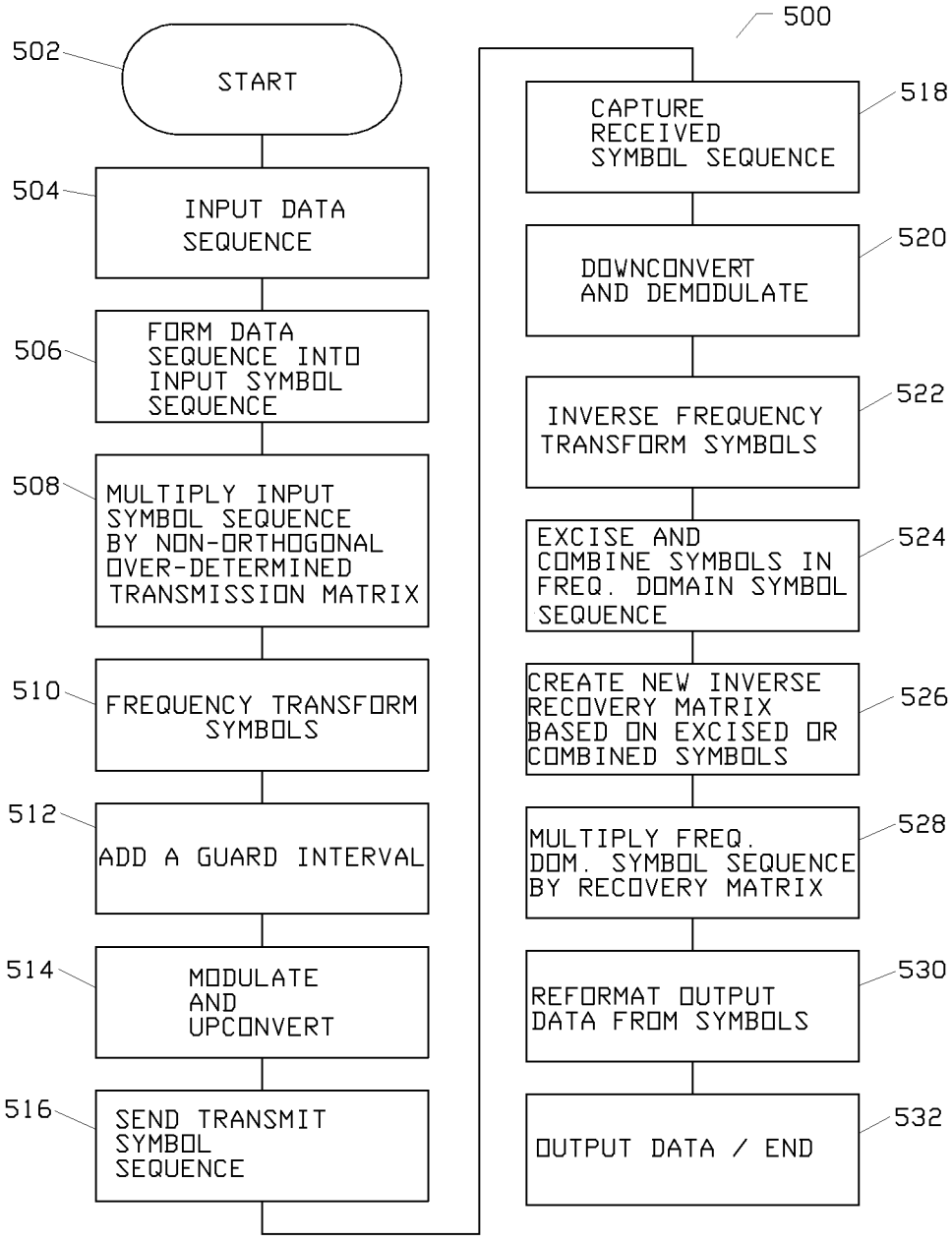

FIG 5